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(54) **Telephone debit card**

(57) A debit card (1), especially for use in a "cashless" telephone, is of the type which is clipped or otherwise defaced for each unit used up and is transparent or has a transparent region which carries one or more patches (2) of an optical responsive material whose characteristics are such that it is not readily forgeable and that it performs an "optical water-mark" function. Verification of a card offered for reading depends on the correct effect due to light incident on the card.

In one form the responsive material is a film, which strongly reflects light incident on it when applied as a parallel beam P but weakly reflects or transmits diffusely applied light S. In another version a circularly polarising film formed by a linear polariser film backed by a quarter-wave plate or retarder is used.

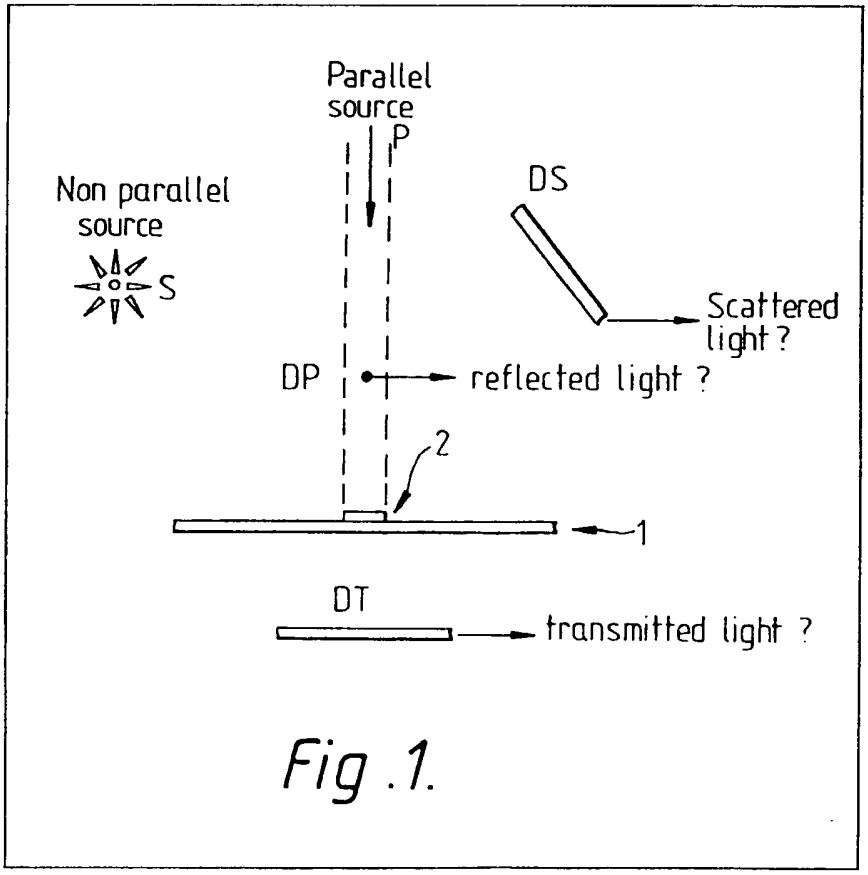

Fig .1.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

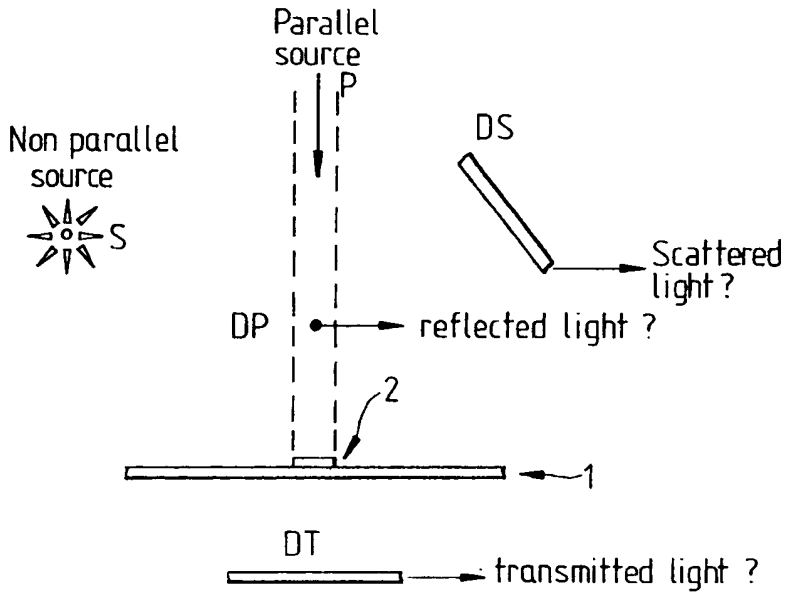
Parallel source
P
Non parallel source
S
DS
Scattered light ?
DP
reflected light ?
2
1
DT
transmitted light ?

Fig .1.

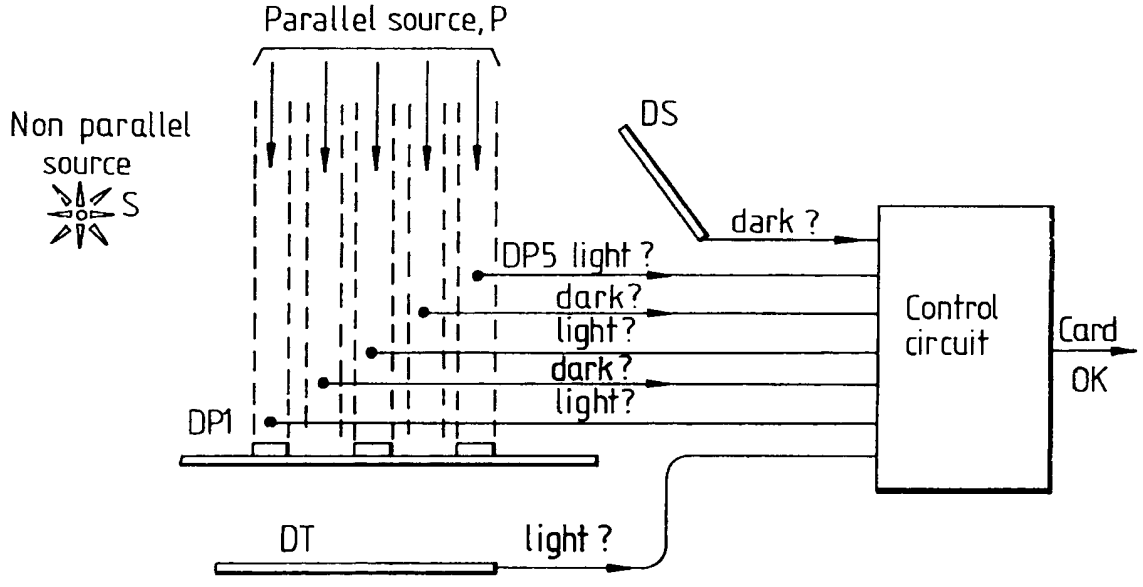
Parallel source, P
Non parallel source
S
DS
dark ?
DP5 light ?
dark?
light?
dark?
light?
DP1
Control circuit
Card OK
DT
light ?

Fig.2.

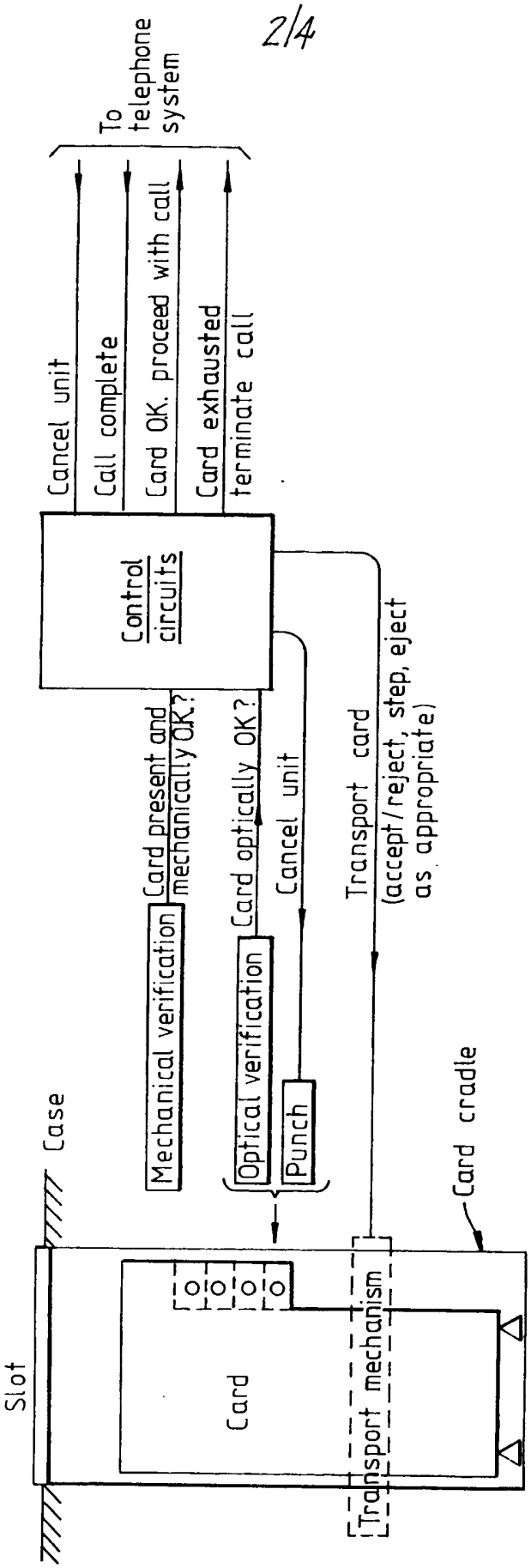
To telephone system
Cancel unit
Call complete
Card OK. proceed with call
Card exhausted terminate call
Control circuits
Card present and mechanically OK?
Mechanical verification
Card optically OK?
Optical verification
Cancel unit
Punch
Transport card (accept/reject, step, eject as appropriate)
Case
Card cradle
Slot
Card
Transport mechanism

Fig. 3.

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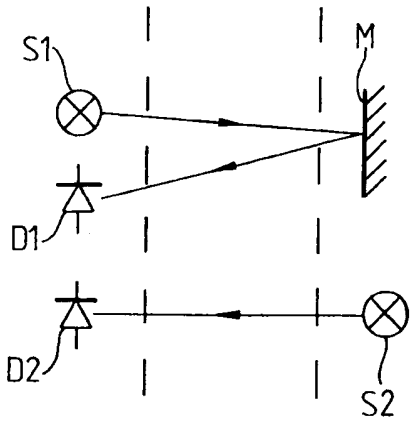

Fig.4a.

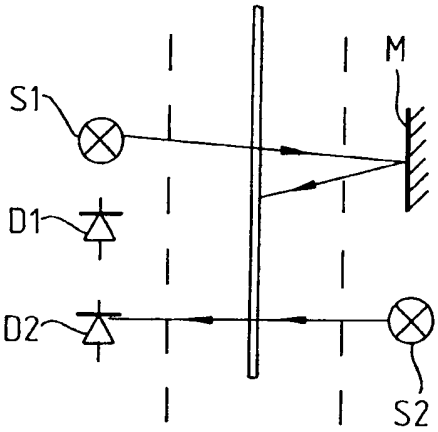

Fig .4b.

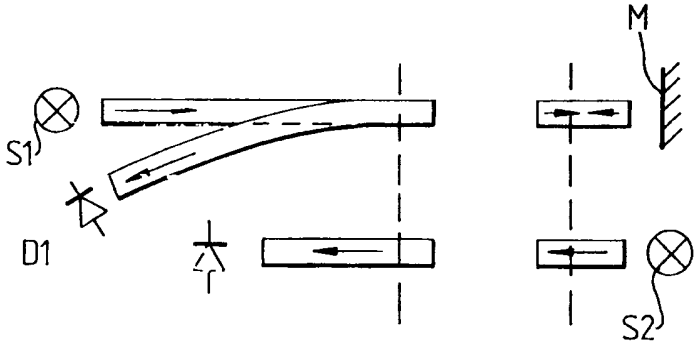

Fig.5.

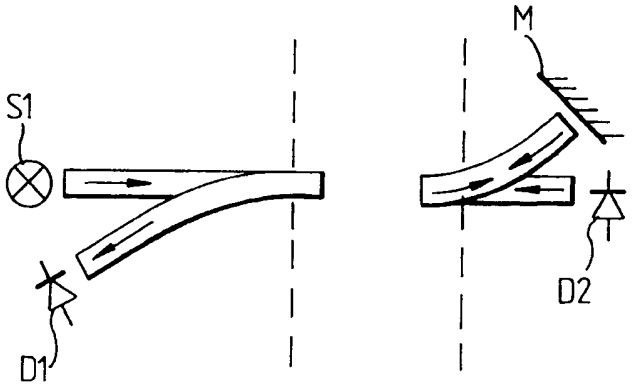

Fig.6.

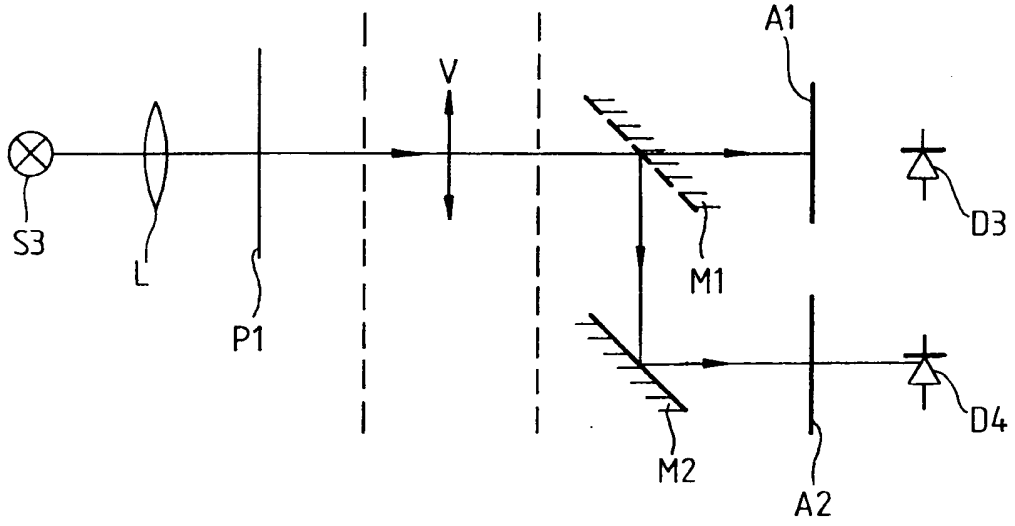

Fig.7a.

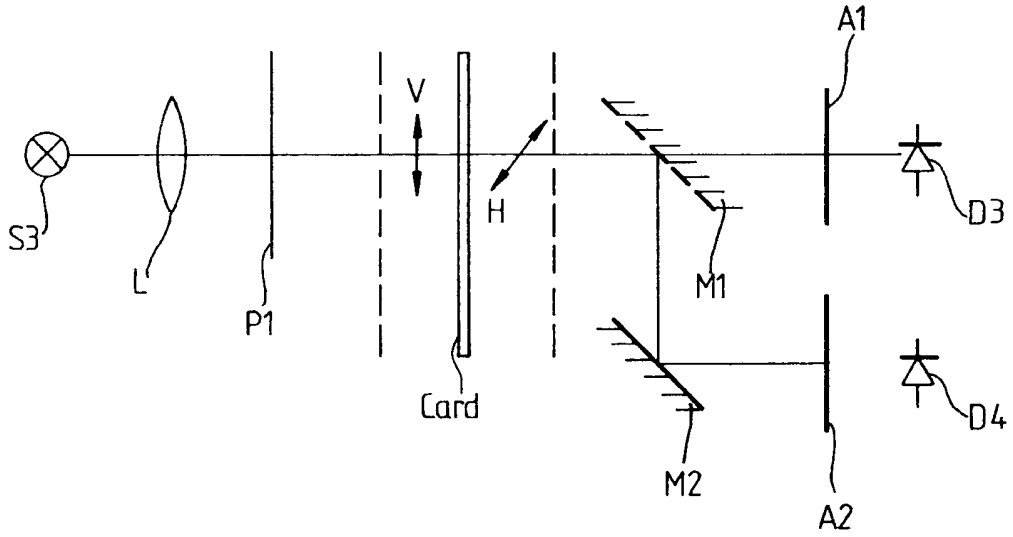

Fig.7b.

SPECIFICATION

Telephone debit card

This invention relates to an intelligence-conveying card for use as a debit card, and to apparatus for use with such a card.

The commonest form of debit card is that much used in public transport, in which a simple card of a specific shape is offered to a reader which, if it accepts the card, clips off a small part of a specified area. This can be repeated a number of times until no more remains to be clipped. Such a simple system is open to fraud, and some security may be added by printing the card with an optically or electrically readable pattern, which may also indicate the value of each unit. These too are often easily forgeable, and it is an object of the invention to provide a debit card of the same general type but with better security.

According to the invention there is provided a debit card of the type which is visually modified by a card reader when a unit is used up, which has on at least one of its surfaces a layer of an optically responsive material which strongly reflects or transmits light incident on it when that light is in the form of a parallel beam from a preset direction but reflects or transmits diffuse light incident on it weakly, whereby a card can be verified by subjecting it to a parallel light beam.

Two optically-responsive materials are used in the manner set out above, one of which is a reflective film marketed by the 3M's Company under the trade mark CONFIRM, while the other is a Polaroid circular polariser.

The CONFIRM reflective film is a transparent film with a layer of microscopic glass beads, with a specific "water-mark" pattern built in by lightly crushing the beads to a predetermined depth. The film is bonded, e.g. by heat, to the surface to be protected, and is invisible (or nearly so) under normal diffuse lighting, although it stands out clearly when illuminated directly, e.g. by a torch beam. Thus direct illumination will make any attempt to tamper with the protected document apparent.

As used herein, one possible method of use is to have a transparent base material overlaid by the film. The reader first checks by reflected parallel light that the correct pattern is present. To check that this is not a fraudulently applied mirror pattern it also checks by transmitted non-parallel light that no pattern can be seen. A fully reflective check by diffuse light is also possible.

The actual reading of the value, and cancellation can then follow established practice.

The special circularly-polarised film, made by the Polaroid Corporation is primarily intended for improving the contrast of luminescent displays by reducing the reflection of ambient incident ligh without affecting the display brightness to any extent. A sheet of a circularly polarising film includes two elements, a linearly polarising film backed by a quarter-wave plate or retarder whose optical axis is at 45° to the plane of polarisation of the linear polariser. Thus ambient light is linearly polarised by the first element while the second element splits the light into two orthogonally polarised components one of which travels slower than the other and suffers a relative phase change of 90°. Hence the light emerging from the second element is circularly polarised in a sense depending on the orientations of the two elements. The sense of rotation of this light is reversed when it is reflected from a specular surface, and when the reflected light falls on the quarter-wave plate the two components are again separated and a 90° phase shift is again introduced. Hence the emergent light is again linearly polarised but now in a plane orthogonal to its original diameter, so it cannot pass through the linear polariser. Thus reflected light is largely suppressed but the light from the display only suffers small loss. Note that the film, whose two elements are obtainable separately has directional asymmetry.

As used in the present system the circularly polarising film can be used in effect as a key to unlock a beam in its transit, so that it can also, in effect, act as a water-mark.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which

Figure 1 is a sketch explanatory of the verification method when using CONFIRM film.

Figure 2 is a typical two-sided application of the principle of Figure 1.

Figure 3 shows the use of an "optical water-mark" with a clipped card system.

From the above comments it will be appreciated that the principle on which the present invention is based is simple: the optically responsive material used produces a different pattern when viewed at the correct angle by reflected parallel light than is seen by reflected or scattered non-parallel light or by transmitted light. Methods of exploiting these properties are based on the ideas illustrated in Figure 1.

A valid card 1 is transparent, and bears one or more reflective patches such as 2, and the card is read by a combination of a parallel light source P and a non-parallel light source S. For a genuine card, strong light is received by a detector DP, which is so located as to catch light from the parallel source P after that light has been reflected from the card, and is also received by a detector DT after it has passed through the card (if one is in place). Relatively weak light is also received by the detector DS, which is arranged to detect scattered and thus non-parallel light from a source S of non-parallel light. The light received by the detectors DT and DS, which latter has a fairly large area compared with the detector DT, does not change very much when the card is removed, but in that condition, DP only receives stray light.

An attempt to force a card using conventional fully or partially reflective patches would fail, since although the detector DP might find the response acceptable, DT would receive too little light and DS too much. Careful design of the pattern printed on the material would give a high degree of security; although a single small reflecting area could be enough to give security, the security would be enhanced by the use of a more complex pattern, the

detector system then looking for light's presence in some places and its absence in others. A simple bar patter is indicated, and Figure 2 shows how this could be read statically using a detector/source combination for each "cell" of a three bar pattern. An alternative is to move a single head and the card relative to each other, either continuously or step-by-step, and to examine the waveshape of the electrical signal produced by the detector. In Figure 2 the optical arrangements are shown in principle, and clearly optical fibers or other light guides can be used to apply and receive the light signals. A single-sided arrangement is also possible using only DP and DS, which would facilitate reading external to the case of the card reader. Such an arrangement would have the merit of being less susceptible to vandalism.

The application of the above principles to the verification of a simple mechanically clipped/punched card is illustrated in Figure 3, which is a reader for a cashless telephone. The reader of Figure 3 relates specifically to a card on which the "optical water-mark" medium is the circularly polarising film, although with suitable optical devices it is equally applicable to a card using CONFIRM film. With the circularly polarising material the detectors have to respond to light whose polarisation states have been altered as described above.

Apart from the optics the operation of the card reader illustrated in Figure 3 is fairly conventional. Thus the card is offered to the machine via a slot; and when the reader has detected its presence, e.g. by a sensing microswitch, the machine seizes the card and takes it into the machine where its size and shape are examined. This gives the mechanical verifications needed. Thus the reader performs the optical verifications, and only after both verifications have been effected does it energize the lead marked "Card O.K.; proceed with call". Then the associated telephone exchange sets up the required connections, and in response to each metering unit a signal on the "Cancel Unit" lead causes debiting to occur by clipping off a piece of the card. The reader thus steps the card on ready to deal with the next unit when so instructed. Eventually the reader is told to stop, e.g. when the caller hangs up in the case of the telephone application, or else finds by mechanical or optical sensing that there are no more units available. It then stops the operation and returns the card to the user. Note that in this case the optical verification checks that there is at least one patch of the "water-mark" material before the card is accepted as genuine.

We now consider the circularly polarising film, marketed by Polarizers UK Limited, and its application to the present invention in a little more detail. Such a film consists of two adjacent elements, a linearly polarising film backed by a quarter wave plate or retarder whose optical axis is at 45° to the plane of polarisation of the linear polariser. Ambient light is linearly polarised by the first element, and the second element splits such light into two orthogonally polarised components one of which travels slower than the other and suffers overall a relative phase change of 90°. Hence the emergent light is circularly polarised in a sense depending on the orientations of the polariser and the retarder.

When used to enhance the contrast of a display such as a cathode ray tube the two elements are placed in front of the tube, which has a specular outer surface. When the light which has passed through the two elements is reflected from this specular surface the sense of rotation of its polarisation is reversed. When such reflected light reaches the circular polariser, the two components are again separated and a 90° phase shift is again introduced. The light emerging from the retarder is thus again linearly polarised but in a plane orthogonal to its original direction so it cannot pass through the linear polariser. Hence the reflected light is largely suppressed, but light from the display is not suppresed, so that contrast is greatly improved.

Such a circular polariser has directional asymmetry in that its effect on light depends not only on the orientations of its axis and the original state of polarisation of the light, but also on the direction in which the light passes through the material. The surface of the composite film with the linear polariser is herein referred to as its face. Thus unpolarised light incident on the face is circularly polarised as is light with any state of polarisation as long as it has a component parallel to the circular polariser axis. Incident light polarised at right angles to the axis is suppressed. If the film is reversed, unpolarised light or light *linearly* polarised in any direction, gets through the film and emerges linearly polarised in a direction parallel to the axis of the material. Circularly polarised light also passes through the material, emerging plane polarised, provided its "band" is correct, if not it is suppressed.

One way to use such a circularly polarising film as the "water-mark" element of a debit card is shown schematically in Figure 4*a* and Figure 4*b*. In the reader/canceller, see Figure 4*a*, light from a source S1 is directed on a mirror M and reflected back to a photodetector D1. A second source S2 in the same plane as the mirror directs a light beam to a photodetector D2 in the plane of S1 and D1. When the "water-mark" section of a card formed by a circular polariser is placed between the two sides, which could be the opposite sides of a card-inserter slot, the reflection from the mirror M is suppressed but light from the source S2 is not. Thus with no card (or no genuine card) in the slot both detectors are lit, whereas with a genuine card only D2 lights. Note that with a spurious card, either both D1 and D2 are lit, or neither is lit.

In a single source arrangement, only S1 is used, with the second photo-detector in the place occupied by S2 in Figure 4. Then the second detector receives light in the no card and the genuine card conditions, while D1 still has its light cut off by a genuine card.

Additional checks are possible: thus an additional interogating beam, either from a separate source or from S1 after reflection from a different part of the mirror M can traverse the card, by-passing the polarising film. Checks can also be made on the state of the beam received by the photo-detector. Thus in the arrangements described above the light is linearly or circularly polarised respectively, which

can readily be checked by extra detectors.

To avoid fraud due to simple holes in the card, the polarisation checks are helpful. In addition the use of relatively narrow beams and half-silvered mirror can be used so that reflected light returns to D1 by the same path as the original signal.

Practical double and single source arrangements using fibre-optic bundles are shown in Figures 5 and 6, where the arrows in the fibre optic bundles indicate the direction(s) of light travel in those bundles.

Such a circularly polarised film is also usable in a mode in which it "unlocks" light which is normally blocked by crossed Polaroid devices. This is shown schematically in Figures 7*a* and 7*b*. The reader consists of a photo-detector D3 locking at a source S3 via crossed polarisers P1 and A1 and a lens L and thus normally "seeing" nothing. P1 is a vertical polariser and A1 is a horizontal polariser. If a card is interposed as in Figure 7*b*, the circularly polarised region of the card causes the plane of polarisation of the light is effectively rotated by 90°, thus "unlocking" so that D3 now receives light. A second check is provided by the use of a second detector D4 covered by an analyser A2 whose axis is parallel to that of P1, with light reaching it via a partially reflecting mirror M1 and a normal mirror M2. Thus D4 receives light in the absence of a card but not when a card is present, i.e. the increase of the conditions for D3.

It should be noted that the light sources used in the arrangements described above could be infra-red sources, i.e. sources of the so-called black light. In such case the light sensitive patches are covered with a filter material which passes infra-red light but not visible light. This would make it more difficult for the forger as the underlying mechanism would not be readily apparent.

CLAIMS

1. A debit card of the type which is visually modified by a card reader when a unit is used up, which has on at least one of its surfaces a layer of an optically responsive material which strongly reflects or transmits light incident on it when that light is in the form of a parallel beam from a preset direction but reflects or transmits diffuse light incident on it weakly, whereby a card can be verified by subjecting it to a parallel light beam.

2. A debit card of the type which is visually modified by a card reader, e.g. by clipping off or defacing a portion of the card when a unit is used up, which card is of a transparent material or has an area of a transparent material with one or more regions of an optically responsive material on the transparent material, in which the optically responsive material strongly reflects light incident on it when that light is in the form of a parallel beam from a preset direction but reflects or transmits diffuse light incident on it weakly, whereby a card can be verified by subjecting it to light inducing a parallel beam of light.

3. A card reader for a card as claimed in claim 2, in which the light is applied as a parallel beam from which light is both reflected by and passed by the optically responsive material, in which detectors are provided which respond to the strongly reflected light due to the beam and to the less strong light reflected from and transmitted by the optically responsive material.

4. A debit card of the type which is visually modified by a card reader, e.g. by clipping or defacing a portion of the card when a unit is used up, which card is of a transparent material or has an area of a transparent material with one or more regions of an optically responsive material on the transparent material, in which the optically responsive material is a composite film consisting of a linearly polarising film backed by a quarter-wave or retarder film whose optical axis is at 45° to the plane of polarisation of the linear polariser, so that the composite film circularly polarises light passing through it, and in which verification is effected by subjecting the region of the card which includes the composite film to a beam of light, such that the effect of the film on the beam is examined to see if the card is genuine.

5. A card reader for a card as described in claim 2, which has a slot with a first light source on one side, a mirror on the other side and a photo-detector on said one side, such that in the absence of a card in the slot light from the source is reflected back to the photo-detector, in which a second light source is located on the other side of the slot in alignment with a second photo-detector on the one side of the slot, and in which when a genuine card is in the slot the reflected light from the mirror is cut off but not that from the second light source.

6. A card reader as claimed in claim 5, modified in that only one light source is used, light incident on the second detector reaching it by reflectors from a different portion of said mirror thus that used for the first photo-detector.

7. A card reader for a card as claimed in claim 4, which includes a slot on the two sides of which are located crossed linear polarisers, such that light is normally blocked, and in which the insertion of a genuine card unblocks the light.

8. A debit card substantially as described with reference to Figures 1 to 3 or Figures 4 to 7 of the accompanying drawings.

9. A debit card reader substantially as described with reference to Figures 1 to 3 or Figures 4 to 7 of the accompanying drawings.

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